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ABSTRACT

This paper addresses three major questions: (1) What can be done at the preservice and inservice levels to help teachers become more effective teachers of numeracy? (2) How can teachers be supported to teach numeracy more effectively to children from various ethnic, indigenous, and socio-economic backgrounds? and (3) What are the responsibilities of teacher educators and those who cater to the continuing professional development of teachers in numeracy? As well as addressing these questions, the current status of professional development, from a research and practical perspective both nationally and internationally, is discussed. The goal is to raise and discuss issues that may affect teachers implementing a numeracy education agenda and to inform those responsible for making decisions about the development of approaches and future directions of numeracy education at the preservice and inservice levels. (Contains 81 references.) (MM)

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Supporting Teachers To Implement a Numeracy Education Agenda

Janette Bobis

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Supporting teachers to implement a numeracy education agenda

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Note

This paper was prepared in 1998/1999 and some information in the paper may not reflect more recent developments.

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Contents

Introduction 3
Effective teachers of numeracy 5
Professional development of practising teachers 9
Preservice teacher education 26
Conclusion 36
References 37

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Introduction

The professional development of teachers is accepted almost universally as critical to the advancement of educational effectiveness (Australian Association of Mathematics Teachers, 1997; Crévola & Hill, 1997; DEETYA, 1998; Department for Education & Employment, 1998; Hargreaves, 1997; National Council of Teachers of Mathematics, 1991; Shimahara, 1998) and is based on the rationale that professional development will improve the quality of teaching and, ultimately, lead to better outcomes for students (Hill, Rowe, Holmes-Smith & Russell, 1996; Schools Council, 1990). Given this crucial role of professional development, its planning and implementation should not be left to 'fate' but should be shaped by the active intervention of all educators who understand that if we want high standards of literacy and numeracy 'we have to create superb professional learning' for teachers at *all* levels of education (Hargreaves, 1997, p. 108).

In 1997 Commonwealth, State and Territory Education Ministers agreed to a national literacy and numeracy goal:

> That every child leaving primary school should be numerate, and be able to read, write and spell at an appropriate level.

Furthermore, they agreed to the subgoal:

> That every child commencing school from 1998 will achieve a minimum acceptable literacy and numeracy standard within four years (DEETYA, 1998a, p. 9).

In conjunction with this, a national plan was endorsed to support the goals. The National Plan includes early assessment of all students and the identification of students considered to be 'at risk', early intervention, regular assessment against agreed national benchmarks and national reporting of student achievement. The plan also recognises the importance of providing professional development to improve literacy and numeracy learning outcomes of all students. While the focus of this paper is on supporting teachers to improve numeracy outcomes, it will also draw upon some important lessons learned from literacy.

Before strategies for professional development in numeracy can be implemented, it is imperative that they be based on best practice and be planned carefully. Hence, major questions need to be addressed: namely, what can be done at the preservice and inservice levels to help teachers become more effective teachers of numeracy? How can teachers be supported to teach numeracy more effectively to children from various ethnic, Indigenous and socio-economic backgrounds? What are the responsibilities of teacher educators and those who cater for the continuing

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professional development of teachers in numeracy? The purpose of this paper is to address these and related questions, and to document the current status of professional development, from a research and practical perspective both nationally and internationally and from various sectors of the community (government and non-government). The aim is to raise and discuss issues that may affect teachers implementing a numeracy education agenda and to inform those responsible for making decisions about the development of approaches and future directions of numeracy education at the preservice and inservice levels.

Professional development

Before proceeding, it is important to clarify what is meant by 'professional development' as it relates to numeracy education and in the context of this paper. This does not mean that *one* particular definition for professional development will be forwarded, as many abound in the literature, rather, that the very concept of professional development for teachers be reconceived. For example, the report — *Numeracy = Everyone's Business* (AAMT, 1997) indicates by its title that professional development should be perceived as being broader than just 'teacher' professional development. It includes 'all the key professional stakeholders...Teachers and educational managers in primary schools, mathematics and non-mathematics teachers as well as educational managers in high schools and teacher educators' (p. 31).

This broader conception has implications for the type and scope of professional development offered. It is based on the rationale that primary school teachers and teachers of mathematics are not responsible solely for improving national numeracy levels. It is a perspective already adopted by numeracy projects operating in Australia. For instance, the Numeracy In Schools Project (NISP) operating in the Northern Territory, has endeavoured to spread the importance of numeracy being 'everyone's business' through its involvement in professional development initiatives coordinated by various associations. The Australian Early Childhood Association, the Australian Council of Educational Administration, the Parents as Teachers Association, the Australian Literacy Educators Association, the Isolated Children's Parents Association and the Language Teachers Association of the Northern Territory are a few of the professional associations that have already conducted numeracy awareness sessions for their members (Scott, 1998).

For the purposes of enhancing numeracy across the curriculum, professional development that includes non-mathematics personnel is in accord with current accepted definitions of numeracy. That is, that 'numeracy involves using some mathematics to achieve some purpose... in a particular context' (AAMT, 1997, p. 15)

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and that a person can be considered *more* or *less* numerate depending on the situation rather than being *numerate* or *innumerate*.

Furthermore, the broader perspective advocated in *Numeracy = everyone's business* acknowledges the fact that teachers cannot be expected to fulfil the national numeracy goal in isolation; they need support from administrators at the school and system levels, from parents and the general community. While the type of professional development needed for each group will differ, it is important that key elements for enhancing numeracy are held in common. This can only be achieved if the professional development net is cast wider than to include just teachers. The challenge here will be to convince non-mathematics teachers and perhaps other educational stakeholders, such as parents, principals, community leaders and educational authorities, of their responsibility in achieving enhanced numeracy levels rather than them viewing it as someone else's role.

Turning to more conventional, and more general, definitions of professional development, no specific one is presented. However, some important overarching elements consistently occur throughout the literature and have implications for the numeracy education agenda. Namely, it is a process that is continuous and career-long and therefore must take account of the different stages in teachers' careers. It can occur both formally and informally as part of the everyday work of teachers, it may involve development in a range of beliefs and attitudes that support more effective teaching practices, the ultimate aim being enhanced learning outcomes for students. Hence, the view of professional development taken in this paper encompasses not only teachers at various stages of their careers (though the paper will predominantly be concerned with teachers as a whole), those involved in initial teacher education through to the more experienced teachers, but also includes non-teaching personnel identified as key stakeholders in numeracy education.

Effective teachers of numeracy

The term 'effective' is used continuously throughout the literature on professional development. As mentioned earlier, research evidence abounds indicating that 'the key to improved learning outcomes is teacher effectiveness' (Hill et al., 1996, p. 45). However, before we can consider what practices can lead to more 'effective' teachers, it is important to clarify what is meant by 'effective teachers of numeracy'. For example, what qualities does an effective teacher of numeracy possess? Can we identify the qualities of an effective teacher of numeracy and then replicate them in others via professional development?

In terms of mathematics content knowledge, research shows that many teachers', and in particular, primary school teachers', own mathematical understandings are

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limited (Kennedy, 1991; Speedy, 1988). It has been suggested that improving teachers' own mathematics knowledge base will lead to better teaching (Alexander, Rose, & Woodhead, 1992; Speedy, 1988). While this conclusion seems logical and is no doubt desirable, there is little research evidence to support this in practice. In fact, there is little agreement and even less research evidence about what actually works in terms of bringing about effective learning of numeracy (Askew, Brown, Rhodes, Johnson & William, 1997; Rhine, 1998).

In a study financed by the Teacher Training Agency (TTA) in England, Askew et al. (1997) sought to distinguish the key factors which enable teachers to put effective teaching of numeracy into practice at the primary school level and to identify strategies which would enable those factors to be more widely applied. They defined effectiveness on the basis of learning gains. Hence, teachers were identified as 'highly effective if their classes of pupils had, during the year, achieved a high average gain in numeracy in comparison with other classes from the same year group' (p. 4). While numeracy was defined solely in terms of 'numerical information', it went beyond referring to simply the accuracy of arithmetical calculations and included 'conceptual understanding of number, a "feel for number", and the ability to apply arithmetic' in a variety of contexts (p. 7). Although such a definition of numeracy does not encompass space, measurement and chance and data as in the Australian context, the results of the study still have relevance and implications for the concerns of this paper.

In short, the project explored the knowledge, beliefs and practices of a sample of 90 teachers, selected from 11 primary schools (government and private) in three different localities, and incorporated data on over 2000 pupils in terms of learning gains. What they found distinguished highly effective teachers from other teachers, more than anything else, was a particular set of coherent beliefs and understandings which underpinned a particular array of teaching practices. In short, highly effective teachers' beliefs related to three main areas:

- what it means to be numerate;
- the relationship between teaching and the pupil's learning of numeracy; and
- the presentation and intervention strategies employed in their classroom practices.

Highly effective teachers believe that being numerate requires a rich network of connections between different mathematical ideas and being able to select and use strategies which are efficient and effective. They believe that almost all pupils are able to become numerate and that pupils develop strategies and networks of ideas by being challenged to think, by being encouraged to explain, listen and solve problems. Highly effective teachers of numeracy use teaching strategies which challenge all pupils, not just the more able, and build upon children's existing mental strategies

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helping them to become more efficient. In relation to teaching, Askew and his colleagues found that highly effective teachers believed that discussion of concepts and images played an important role in developing networks of knowledge and skills and in revealing students' thinking. They also found that these teachers believed that it was their responsibility to intervene to assist students to become more efficient in the use of calculating strategies.

This set of beliefs was manifest in ce ain classroom practices and outcomes that were commonly observed amongst t ose identified as highly effective teachers of numeracy. For instance, teachers who gave priority to students developing networks of interconnected understandings in mathematics, rather than the acquisition of standard algorithms, produced higher numeracy gains in their students. Similarly, students of teachers who focusses on the gradual development of more sophisticated methods and strategies for handling abstract concepts, achieved higher numeracy gains than those who were denied the introduction of more abstract ideas.

In addition to a well developed set of beliefs that underpinned their classroom practices, it was found that 'highly effective teachers of numeracy themselves had knowledge and awareness of conceptual connections between the areas which they taught in the primary mathematics curriculum', but that this was *not* associated with having high levels of formal education in mathematics (Askew et al. 1997, p. 3). It was also found that highly effective teachers were more likely than other teachers to have undertaken mathematics-specific[1] continuing professional development over an extended period, of at least 15 days equivalence. They not only perceived this to be a significant factor in their development of teaching strategies, but to contribute to their very positive attitudes towards mathematics in general. This was in contrast to many teachers who had specialist mathematical qualifications, but attended only one to three days of professional development in mathematics and possessed poor attitudes towards mathematics.

It is impossible to say, without further investigation, whether these findings can be extrapolated to secondary mathematics teachers, particularly in regard to the relationship between level of study and teacher effectiveness. We are also unable to confirm from the results of just one study whether students' gains in numeracy were as a direct result of their teachers receiving extended professional development or whether the better teachers were attracted to doing more professional development in mathematics in the first place. Askew and his colleagues did not investigate whether teachers who possess the highest formal qualifications in mathematics *and* attended extended periods of mathematics-specific professional development were more effective teachers of numeracy than their colleagues who possessed fewer

[1] Where content or strategies is treated with specific reference to the teaching of mathematics, as opposed to sessions dealing with topics more generally, such as problem solving

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formal qualifications but attended extensive periods of professional development. What does seem certain, is that while having an extended knowledge base of mathematics is helpful, it is not necessarily enough to ensure a teacher is effective. What matters more is the nature of that knowledge.

Teachers need to understand the interconnectedness of mathematics concepts and possess a good 'mental map' of pupils' lines of development in order to teach numeracy effectively (Askew, et al., 1997, p. 115). By 'mental map', it is meant that teachers understand certain stages of development that children progress through, say, in regard to their strategy use. For example, to calculate 4 + 5, a common strategy used by young children is to count all numbers starting from one to four and then to keep counting five more while keeping track with their fingers until they arrive at 'nine'. A more sophisticated strategy is to count-on from the larger number, in this case, five, until four more is reached. Knowledge of such strategy development allows a teacher to identify where a child is 'at' and to know where a child may need assistance to progress to the next stage of development. Thus, a teacher possesses a type of 'map' for each child's mathematical development.

The results of this study have implications for the professional development of teachers (in particular, primary school teachers) at all stages of their careers and bring into question many initiatives already put in place with the intention of improving the effectiveness of our teachers. For example, the NSW Department of Education and Training (DET) sought to increase primary teachers' knowledge base in mathematics by issuing the directive that all primary school teachers employed by DET must have completed 2 units of mathematics to the HSC level. Similarly, many initial teacher education programs at universities have, in response to the recommendations in *The Discipline Review of Teacher Education in Mathematics and Science* (Speedy, 1989) for increasing the knowledge base in mathematics and science of our primary school teachers, instituted compulsory mathematics content-based subjects into their initial teacher education programs (for example, University of Technology, Sydney, the University of Western Sydney, Macarthur and Flinders University, Adelaide). It is impossible to comment on the outcomes of these initiatives in regard to increasing the effectiveness by which numeracy is taught without follow-up research, but in the light of findings by Askew et al. (1997) we need to question whether they are sufficient to enhance teacher effectiveness in numeracy especially since research indicates that generally primary school teachers report having bad experiences of mathematics as a learner (Bobis & Cusworth, 1994) and usually regard their initial teacher education has having little impact on their effectiveness as a teacher (Hargreaves, 1997).

In summary, while research into the qualities of an effective teacher of numeracy are still very limited and warrant further investigation, particularly at the secondary level, the findings of Askew et al. (1997) indicate the importance of:

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- a positive attitude towards mathematics;
- a coherent set of beliefs that underpin certain classroom practices; and
- a well developed understanding of the interconnectedness of numeracy.

The findings also indicate that there is some relationship between these qualities and the professional development undertaken by these teachers. We therefore need to ascertain whether these qualities can be replicated through professional development. If so, what aspects of professional development and teaching experience could result in these teachers forming the beliefs and practices which accompany effective teaching of numeracy? These and related questions will be addressed in the next section on the professional development of practicing teachers.

Professional development of practising teachers

A continuing concern regarding professional development is its ability to change classroom practices and to achieve long-lasting effects. Despite this, we now know an enormous amount about how to make the professional development of teachers more successful generally, thanks to the dissemination of research literature (e.g. Fennema, Carpenter, Levi, Jacobs, & Empson, 1996; Louden, 1994; Retallick, Hill, Barton, Cocklin & Sparrow, 1994) the documentation of successful professional development programs (e.g. Bobis, 1996; 1997; Hill & Crévola, 1997; Stewart, 1998) and the release of reports by professional organisations (e.g. Queensland Consortium for Professional Development in Education, 1998). Before summarising the major points raised by this body of literature and relating them specifically to the effective teaching of numeracy, it is helpful to examine a profile of Australia's teaching force from which implications can be drawn regarding how teachers might be supported to implement a numeracy education agenda.

In 1997 there were approximately 207 000 full-time teachers employed in Australian schools (Ministerial Council on Education, Employment, Training and Youth Affairs [MCEETYA], 1999). Of these, 70.3 per cent taught in government schools, 50.1 per cent of these were primary. The total number of full-time permanent teachers increased by 1.5 per cent on the previous year. While growth occurred in all eight states/territories, it was not uniform. Queensland showed the most marked increase in growth from 1996 to 1997 at 3.6 per cent and Victoria showed the smallest growth at 0.5 per cent.

Issues surrounding the continuing fluctuations in the supply and demand of teachers have been a concern to the educational community for decades (Galbraith, 1999). Implications have been extrapolated from the data in various ways (National Council for Vocational and Education Research [NCVER], 1998; Preston, 1997). Such

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variations reflect the complex nature of issues surrounding the supply and demand of teachers.

In 1998 a report was prepared by the National Teacher Supply and Demand Working Party (Conference of Education System Chief Executive Officers [CESCEO], 1998) that examined the trends in demand and supply for both primary and secondary teachers. It concluded that, overall, a sufficient supply of qualified teachers should be available to meet an expected slight increase in demand for teachers over the period 1998 to 2001. It argued that low demands during the 1990s has resulted in a 'pool' of potential teachers that will augment the supply of new graduates. The report also concluded that the projected increase in growth of secondary school enrolments and the likely increase in Year 11 and 12 retention rates due to government changes in youth income support could exacerbate recruitment difficulties already evident in some specialisations for some regions.

This situation may be further exacerbated by the declining trend in teacher education course enrolments noted since the early 1990s and the expected increase in the age-related attrition rate of government school teachers in the next decade (NCVER, 1998). Mathematics, along with science, industrial arts, languages other than English (LOTE) and physical education are identified as specialised areas currently experiencing such difficulties for some regions (CESCEO, 1998). The report suggests that any potential shortfall in training or in areas of speciality where the supply is inadequate, could be addressed quite quickly by graduates with appropriate bachelor degrees undertaking appropriate postgraduate courses of shorter duration.

Galbraith (1999) argues that predictions of shortfalls are far more problematic and complex than depicted by studies that assume that teacher education institutions will be able to provide the appropriate supply if they know the number required a few years earlier. For example, he points out that predictions of shortfalls made by Preston (1997) 'were based on estimated future values of variables whose accuracy could be affected markedly by variations in the labour market and by variations from the assumed responses by stakeholders' (Galbraith, 1999, p. 3). Instead, Galbraith proposes an approach designed to stabilise the rates of change that cause major fluctuations in the supply and demand of teachers. In his book, *Forecasting Teacher Supply and Demand*, he outlines two models that take account of the complexity of the situation, attempting to stabilise the rates of change and manage the structures responsible for cyclic fluctuations in supply and demand more effectively.

Reports dealing with supply and demand issues have called for the need to improve the status of the profession via improved working conditions, wage increases and subject-specific teacher scholarships (Preston, 1997). Such recommendations are based on the assumption that they would help attract and maintain quality teachers in the workforce. While these elements would no doubt benefit the profession as a

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whole, it would be an oversimplification of the complex issues surrounding supply and demand of teachers to think that such measures would, by themselves, provide a solution to a situation characterised by cyclic fluctuations. Galbraith suggests that short-term emergency measures need to be accompanied by long-term management strategies so as to regulate the severity of such fluctuations. For management to occur, procedures need to be put in place to enable annual monitoring and reporting on the labour market for teachers. Recently, MCEETYA agreed to a mechanism whereby biennial reports on teacher supply and demand can be considered for that purpose (see www.curriculum.edu.au/mceetya/publicat/publica.htm for the CESCEO report *School Teacher Demand and Supply — Primary and Secondary*).

Support for beginning teachers

It can be seen from the data presented, that Australia's teaching force is generally very experienced and quite stable — it is also older than ever before, with more than 40 per cent of its workforce aged over 45 and, 'nearly three-quarters of the industry's workforce' aged over 35 (NCVER, 1998, p. 323). With an expected increase in the rate of age-related attrition in the next decade, the profession will see a gradual infiltration of less experienced teachers as new graduates enter the workforce. These factors need to be considered carefully because they have implications for the nature of professional development deemed to be of most benefit to our teachers.

The necessity of providing effective professional development for our practising teachers is crucial, not only to ensure the effectiveness of the current work force but for the years to come. Given the mature nature of our teaching force, small injections of new skills and desirable qualities that beginning teachers bring to their careers, such as those outlined in the *National Competency Framework for Beginning Teaching* (Australian Teaching Council, 1996), may not be sustainable in a climate of conservatism and conformity. Investigations of beginning teachers' induction into the teaching profession have highlighted the difficulties they experience, building up a 'deficit' model of those entering the profession (Hatton & Grundy, 1994). A large study of beginning teachers in three states found that nearly half of the sample surveyed rated their induction to teaching as ineffective (Department of Employment, Education & Training, 1991). Other studies have examined the problems of beginning teachers and have demonstrated the 'reality shock' experienced by teachers at the start of their careers (Board of Teacher Registration, 1991). Typically, findings indicate that beginning teachers shift rapidly from progressive, student-centred teaching approaches toward more traditional, teacher-centred approaches in the face of everyday school life (Ballantyne, Hansford & Packer, 1995). Some researchers have suggested that beginning teachers can act as 'agents of change' in schools if their enthusiasm and recent knowledge of curriculum

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and policy documents are valued (Fullan, 1991). Findings from a study by Bobis and Cusworth (1995) indicate that beginning teachers *do* expect to make a contribution to the school community from the very outset of their careers. However, while they may have expertise in particular areas or up to date curriculum knowledge, support from executive staff is crucial in empowering them to have a 'voice' or an expectation that they will be listened to within the school community (Sumison, 1994). It seems that many school contexts actually deny beginning teachers this opportunity to make a positive contribution during their initial years of teaching. However, Ballantyne et al. found that graduates of 'critically reflective' teacher education programs were more likely to retain their progressive, student-centred attitudes and ideals in spite of the pressures and constraints encountered in the initial stages of their teaching careers.

Projects such as Queensland's *Mentoring New and Beginning Teachers Program*, The Board of Teacher Registration *Pilot Induction Project* and *EMSTAR* (Enhancing the immersion of beginning women teachers into Mathematics and Science Teaching through participatory Action Research networks) have been initiated to assist beginning teachers with their transition into teaching. The first two projects listed, while not specifically related to numeracy, utilise the concept of 'on the job' mentoring to 'enhance self-directed professional development' (Smart, 1998, p. 25). The *Mentoring New and Beginning Teachers Program* was established to support and guide new and beginning teachers via supportive collegial networks within and among Queensland schools. The project started in 1996 with twenty-three 'volunteer' experienced teachers from fourteen primary schools and special schools in the South Coast Region of Queensland attending a two-day mentoring professional development program. As a follow-up, networks were established between the teachers and a facilitator from Griffith University. In her report on the success of the project, Smart (1998) comments that 'this program provides a proactive model of professional learning for new and experienced teachers; it encourages and motivates teachers to stay in the profession and it promotes the idea of collegial partnerships...' (p. 30).

Outcomes of the projects utilising mentors suggest that the 'mentors benefit from an increased feeling of self-worth and students from increased self-confidence' (p. 33). In her discussion on the merits for implementing a mentoring system for supporting new and beginning teachers, Smart argues that it is not only 'job-embedded' professional development, but that it is ongoing and thus has the potential to transform workplaces by facilitating long-term change.

Another project aimed at assisting the induction of beginning teachers is the *EMSTAR* project (Atweh & Heirdsfield, 1998). *EMSTAR* highlights the benefits of using action research to encourage reflective practice among secondary mathematics and science teachers. A major element of the project was the establishment of a

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network among the beginning teachers, staff from Queensland University of Technology and some experienced teachers. The role of the university lecturers was to act as facilitators for connecting teachers with similar needs and interests and to organise network meetings. Atweh and Heirdsfield found that the network meetings allowed the beginning teachers to share their concerns in a supportive atmosphere and helped increase their self-awareness about their practice. However, the project also reveals the limitations of such a model if applied on a larger scale. The vast geographical distances separating participants hindered the ability of some teachers to maintain contact with the network on a regular basis. In the future, this problem may be overcome with the assistance of information technology, but current levels of access to the necessary technology were not adequate (Atweh & Heirdsfield, 1998).

Given the 'reality shock' encountered by many beginning teachers, the fact that employment opportunities have been limited for new recruits and traditional induction programs are considered, generally, to be ineffective, it has been argued that if we want to reform teacher education, 'teacher preparation is the worst place to begin' (Hargreaves, 1997, p. 107). Projects outlined by Smart (1998) that utilise on the job mentoring are in accordance with Hargreaves' conclusion (along with others, such as Bobis, 1998; Retallick et al., 1994 and Sachs, 1997) that the most promising place to start is with partnerships between faculties of education and school systems.

Support for teachers: a focus on the first years of school

The notion of a partnership between faculties of education and school systems is by no means a new one, with many of the numeracy professional development projects operating across Australia already involving partnerships in various forms. A prime example of a collaborative partnership exists in the NSW *Count Me In Too* Project (Bobis, 1996; 1997).

While *Count Me In Too* (CMIT) is a professional development initiative of the NSW Department of Education and Training (DET), focusing on the early years of mathematics, a close working relationship has been maintained with researchers from Southern Cross University, Macquarie University and the University of Western Sydney. Its main purpose is 'for teachers to better understand children's mathematical strategies and their development from less sophisticated to more sophisticated strategies' (Stewart, Wright & Gould, 1998, p. 557). It is research based, originating from the theory and methods of the *Mathematics Recovery* (Wright, Stanger, Cowper & Dyson, 1996) and *Reading Recovery Programs* (Clay, 1993) incorporating aspects such as the Learning Framework in Number (Wright, 1998) and a clinical interview based assessment instrument — the Schedule for Early Number Assessment or SENA (DET, 1998). Rather than being a packaged program, *CMIT* is a continually evolving school-based initiative that involves a close liaison

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between the district consultant and a group of teachers at each school. A major outcome of the project is the establishment of collegial groups, where professional dialogue relating to mathematics flourishes. These two aspects of the project — work-based learning and collegiality — are well acknowledged as being crucial factors to the success of other professional development projects (Billett, 1998; Retallick et al., 1994; Retallick & Groundwater-Smith, 1996).

The work-based model of professional development operating in *CMIT* schools varies from school to school, but generally there is much more focus on children's solution strategies, on reasoning, reflection, problem solving and conceptual understanding rather than on the rote memorisation of algorithmic procedures. A video-taped clinical interview referred to as the Schedule for Early Number Assessment (SENA) is an integral component of the program. It is used to diagnose children's strengths and weakness, providing teachers with a 'blueprint' of each child's arithmetical development. Guided by results on the SENA and the Learning Framework in Number, teachers are able to map future lines of development for children on an individual basis. Currently, implementation is focussed on number, however a research base in Space and Measurement is being developed that can be implemented in a similar fashion.

The success of *CMIT* and *Mathematics Recovery* is evidenced by their gradual adoption (and adaptation) both nationally and international. For example, *Mathematics Recovery* has been growing in its implementation in the United States since 1995 (Wright, Stewart, Stafford, & Cain, 1998) and in the UK since 1996 (Stewart, 1998). In the United Kingdom, staff from Liverpool University have been collaborating with educational authorities of Bury, Wigan and Sefton Metropolitan Boroughs to implement *Mathematics Recovery*. The project is seen as complementary to England's *National Numeracy Project* (NNP) which has been operating since 1996, because it deals mainly with the lower 30 per cent of children and the NNP aims at raising numeracy levels of *all* students (Department for Education and Employment, 1998). As with *CMIT* and *Mathematics Recovery* programs operating in Australia, the UK version incorporates elements considered to be crucial to its successful implementation. That is, it is research based. Teachers receive instruction regarding the Learning Framework in Number, the use of video-taping for reflection and analysis is emphasised. Training to implement the clinical assessment interview (SENA) and instruction regarding teaching approaches are provided to teachers both in their schools and at the University of Liverpool. While *Mathematics Recovery* is currently viewed as an intervention program for 'at risk' children, its recent evaluation has indicated its potential as a whole class teaching program as applied in the *CMIT* project operating in NSW (Stewart, 1998). An advantage for the teachers involved in the UK *Mathematics Recovery* program over their Australian *CMIT* counterparts, is that they receive a Certificate in the Advanced Study of Education

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(CASE) and accompanying Professional Journal (required for the CASE), from the University of Liverpool on completion of their training. Such accreditation not only acknowledges teachers' newly acquired expertise on a more formal level, but assists teachers when applying for promotions and can be credited towards completion of university level courses.

While CMIT and *Mathematics Recovery* have focussed on K–2 students, an initiative to combine the successful elements of both these programs along with aspects of the successful *Cognitively Guided Instruction* program (Fennema et al., 1996) of the United States was instigated in 1998 by Auckland College of Education, in collaboration with educational authorities in Auckland, New Zealand to target Year 3 students. Materials produced by the NSW DET to support the implementation of the *Count Me In Too* Project have been incorporated into the New Zealand package (Hughes, 1997). CMIT and *Mathematics Recovery* seminars have also been held in Hobart in conjunction with the *Flying Start Numeracy Program* (Wright, 1998) and recently the Catholic Diocese of Canberra/Goulburn has indicated an intention to implement CMIT (Hughes, 1998).

As with the CMIT program in NSW, the *First Steps in Mathematics* project in Western Australia, is based on an evolving research base due to the close links between the Education Department of Western Australia and mathematics educators at Murdoch University. While adopting a much wider initial implementation status than CMIT, incorporating number, measurement and space strands, it targets the first three years of school, is based on whole-class teaching and incorporates a work-based model of professional development similar to CMIT. *First Steps in Mathematics* is still at a research and development stage, and is awaiting additional financial assistance before a system-wide implementation can be initiated.

Numeracy for All (Department of Education, 1994) is another popular professional development program operating in government and non-government schools in NSW, ACT and the northern parts of Victoria. It is also based on research, incorporates clinical interviews as part of the assessment and has an early intervention (K–2) focus. The *1996 National Report on Schooling in Australia* (1998) indicates that in 1996 Catholic schools across NSW were generally using the *Numeracy for All* program. However, reports received from various dioceses indicate that system-wide use of the program existed in some dioceses (for example, the Diocese of Wagga Wagga), but not in others. The attraction of the *Numeracy for All* program is that it can operate in schools independently of the system, it has a comprehensive package of support materials that include readings and blackline masters, and is relatively cheap. However, despite its successful reputation, the program has never undergone a formal evaluation.

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In Queensland an extensive and statewide professional development program in early numeracy accompanied the *Year Two Diagnostic Net* project. As part of the project, a Number Developmental Continuum was developed and trialed in all Queensland state and participating non-state schools in 1995, and is now used by Years 1–3 teachers to monitor and report on aspects of children's numeracy development during the early years of schooling and to identify those children who are experiencing difficulties (Queensland School Curriculum Council, 1997). The professional development component focussed on the developmental continuum, its use in monitoring children's progress and on the enhancement of teachers' knowledge and understanding of children's development of number concepts. Developmental Continua for Space and Measurement and Data are currently being trialled and will be accompanied by similar professional development to support their implementation.

Also in Queensland, the *Support-a-Maths Learner: Number Project* is aimed at enhancing students' numeracy achievements. This project is a state wide, intersystemic professional development program for teacher aides who work closely with classroom teachers in supporting students who are experiencing difficulties in number concepts. Learning Support teachers from across all systems and the state are currently undertaking professional development. They will then educate the teacher aides at their site to help implement the project.

In Victoria the *Mathematics Intervention Program* (Pearn, 1998a; Pearn, Hunting, Merrifield, & Mihalic, 1997) was developed as a collaborative project between educators and La Trobe University and a government primary school. The program was first implemented in 1993 and features elements of *Reading Recovery* and *Mathematics Recovery* such as clinical interviewing and an emphasis on the development of children's mental strategies based on recent research. It is an intervention program that aims to identify and assist children in their first two years of school considered to be 'at risk' of not achieving adequate levels in numeracy as suggested in *A National Statement on Mathematics for Australian Schools* (Australian Education Council, 1991) and the *Victorian Curriculum & Standards Framework* (Board of Studies, Victoria, 1995). As a consequence of the program's success, teachers from eight schools were selected to collaborate with educators from La Trobe University in the *Maths in Schools* (Montgomery, 1996). As part of their professional development, teachers participating in this program undergo training to develop their clinical interviewing skills, and are provided with supervised experiences to develop their skills at interpreting children's mathematical strategies (Pearn et al. 1997).

In a follow-up study, Pearn (1998b) investigated the progress of children involved in the *Mathematics Intervention Program* to determine if further intervention was needed for these students in Years 3 and 4. She found that all children had improved considerably in their numeracy skills since Year 1, but that there was still a small

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group of students who were not achieving at the level predicted by their Year 1 results (p. 450). Pearn concluded that further intervention is necessary for a small number of students in Years 3 and 4 even after undergoing intervention at Year 1 or 2. The finding highlights the need for professional development of teachers of middle and upper primary classes regarding monitoring numeracy standards and applying intervention strategies for children who continue to experience difficulty even after intervention has occurred in previous years.

This 'third wave' of teaching notion concurs with the approach advocated by proponents of *Reading Recovery* (Clay, 1993) and adopted by Crévola and Hill (1997) in the *Early Literacy Research Project* (ELRP) operating in Victoria. Basically, the 'three waves of teaching' refer to target estimates of students achieving acceptable standards of reading and writing. At the first wave, it is expected that 80 per cent of students will achieve acceptable standards in their first year of schooling having been exposed to 'effective teaching' in a normal classroom setting. Students identified as not achieving acceptable standards then undergo a second wave of teaching that involves appropriate one-to-one intervention. It is anticipated that a further 18 per cent will reach acceptable standards by the end of this second wave of teaching. A final 2 per cent of students are left requiring further 'third wave' support during their third year of schooling on a one-to-one basis. The success of ELRP has resulted in the Victorian Department of Education conducting the *Early Numeracy Research Project* (ENRP) incorporating the key design elements of a General Model of School Improvement used by Crévola and Hill in ELRP. The whole-school design incorporates nine elements that reflect a compilation of the latest research findings regarding 'effective teaching' in the general classroom:

1. Beliefs and understandings
   Inherent in the design is the belief in the capacity of all students to make progress, given sufficient time and support.
2. Expectations and targets
   High expectations are indicative of effective schools. The targets for student achievement levels is expressed in the 'three waves of teaching' notion.
3. Monitoring and assessment
   This element is based on consistent research findings that effective teachers regularly assess their students' progress so as to keep challenging them to work at the 'cutting edge'.
4. Structured classroom teaching program
   Teaching which is structured and focussed on the learning needs of each student is indicative of more effective teaching. This requires a well developed understanding of how children learn.
5. Professional learning teams

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The provision of effective, ongoing, professional learning for teachers related to their classroom practice is considered to be 'the most important element' of the program (Crévola & Hill, 1997, p. 10). Key components included the forming of collegial learning teams, training to assess and analyse students' work, theoretically-based yet practically-situated learning, opportunities to observe good practice, time for reflection, 'outside' classroom days and school visits by the university-based professional development coordinator (Hill & Crévola, 1998).

6. School and class organisation
   School and class organisation needs to be such as to maximise engaged learning by ensuring it is uninterrupted and focussed on the needs of the students.

7. Intervention and additional assistance
   Even with highly effective first-wave teaching, it is acknowledged that a significant proportion of children will not achieve satisfactory levels. Intervention at the earliest point is essential for these children.

8. Home, school and community partnerships
   The importance of sustaining strong links between home, school and the community is recognised in whole-school designs of school improvement. In particular, the pre-school years are considered to be crucial to providing appropriate experiences in preparation for school.

9. Leadership and coordination
   In effective schools, strong leadership has been identified as a significant element. This means that principals and coordinators play a key role in any project designed to enhance the effectiveness of teaching.

Only the fifth point specifically relates to professional development, however all nine elements would require some form of support.

While ELRP has proved successful, we must take heed of the 'notion that literacy and numeracy are distinct areas' and 'are underpinned by fundamentally different areas of learning' (AAMT, 1998, p. 2). As a consequence, increasing the teaching effectiveness of numeracy may require design elements distinct from literacy: what works for literacy may not work for numeracy. However, it will be noted that many of the nine elements summarised above have already been mentioned as key elements in successful numeracy professional development projects operating nationally and internationally.

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Support for teachers of primary and secondary students

In addition to the professional development projects designed to enhance early numeracy, there is a number of initiatives that focus on different aspects of the numeracy agenda, which are still intent on improving the effectiveness of numeracy teaching overall. For instance, Murdoch University staff are collaborating with the Education Department of Western Australia (EDWA) to enhance numeracy standards at both the primary and secondary school levels. A School-based Professional Development Program for K–10 teachers in government and non-government schools operated between 1996 and 1997 to assist teachers with the implementation of student outcome statements. Currently they are collaborating on the *Numeracy Across the Curriculum Project* which aims to 'provide a description of numeracy which EDWA can use in its strategy for improving cross-curriculum outcomes and to develop an approach to numeracy based on the practical experience of teachers. It is hoped that it will help teachers recognise and develop sound classroom practice for the enhancement of numeracy' (Jeffery, 1998, p. 1). Schools with a significant proportion of Aboriginal students and students for whom English is a second language are involved.

In South Australia a project funded and developed by the Aboriginal Education Unit of the Department of Education Training and Employment is aimed at catering for the needs of schools that deal solely with Aboriginal students or which have a high proportion of Aboriginal students attending. The *Contextualising Mathematics Focus Schools Project* (Bleckly, 1998) provides eleven teachers from seven different primary schools with release time to plan, document and share their teaching experiences with the group on a regular basis. The aim of the project is to develop and document contextual teaching and learning practices in mathematics as a means of improving outcomes for Aboriginal students. The *Numeracy 3–10 Research and Development Project* will produce support materials to be used in the professional development of teachers in all schools. The project aims to support all teachers of Years 3–10 to develop an understanding and appreciation of their own numeracy abilities, to develop and implement strategies to assess students' numeracy levels and to identify teaching strategies for enhancing the numeracy development of their students through action research projects. Included in the professional development component is support for teachers of Years 3–5 who will be required to implement the numeracy benchmarks.

A South Australian Consortium, comprising local mathematics teacher associations, the Adelaide Consortium for Mathematics Education (involving staff from all three South Australian universities), teacher unions and parent groups, participated in a Commonwealth funded *National Professional Development Program* from 1993 to 1997. Through a range of professional development modules utilising a variety of delivery

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modes including work-based learning, the project aimed to encourage teachers to address their professional development needs within the context of emerging national initiatives. For instance, teachers were given support to implement curriculum documents such as *A National Statement on Mathematics for Australian Schools* (AEC, 1991) and *Mathematics — A curriculum profile for Australian Schools* (Curriculum Corporation, 1994). The associations conducted workshops for teachers who, on completion of certain assessment requirements, could earn credit towards a Graduate Certificate in Professional Practice. Work-based professional development was also provided to allow teachers opportunities to reflect upon and explore new teaching approaches and assessment practices.

Similar to the aims of the SA Consortium project, was a Commonwealth funded professional development initiative in Queensland operating throughout 1996. The project, *Enhancing Partnerships for Implementing Effective Literacy, Numeracy and Key Competencies Practices in Central Queensland,* saw the collaboration of various universities, teacher unions, professional associations and school systems in an attempt to engage teachers in critical reflective inquiry. The aim was to provide a basis for them to re-conceptualise their classroom practices in line with emerging national priorities across the curriculum.

The professional development initiatives in the Northern Territory reflect the uniqueness of its situation. The large geographic size of the Territory and its relatively small population (approximately 170 000) makes access to any form of educational resource difficult for many. The general isolation of its schools combined with the nature of its population (about 30 per cent of the population is Aboriginal, and a large number of Asian migrants, mainly clustered around the major cities, are ESL) and the fact that most of its teachers are recruited from other states, means that the needs for professional development differ greatly from other parts of Australia.

In a study by Jacob and Frid (1998), designed to investigate Northern Territory secondary mathematics teachers' perceptions of the effectiveness of their preservice and inservice education, it was found that 80 per cent of the teachers responding to the questionnaire component of their investigation had received their education outside of the Territory. It was also found that a large proportion had not undertaken preservice training in mathematics, but were required to teach it due to the shortage of mathematics teachers available. Generally, teachers reported that their preservice education had been of limited value and that continuing professional development was considered to be a key component to their teaching effectiveness. Many teachers 'whose preparation for teaching did not equip them to teach mathematics felt...that in-service professional development had been inadequate in meeting their needs' (p. 284). While teachers employed in the larger urban areas felt that their professional development needs could mostly be satisfied by colleagues, those employed in remote or small schools lacked this opportunity. Jacob and Frid's (1998) study

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highlights some of the unique needs of the Northern Territory's teachers and may have implications for other regions of Australia if the shortfall in appropriately trained mathematics teachers continues. Attempts to meet the predicted increase in demand for secondary mathematics teachers have been initiated at some institutions. For instance, the University of Tasmania offers scholarships to students beginning teacher education in secondary mathematics and graduate certificates in mathematics have been establishment at some universities (e.g. Queensland University of Technology).

On a more positive note, the smaller population of the Northern Territory has been conducive to collaborative projects amongst the various systems and sectors being established. For instance, the *Numeracy in Schools Project* (NISP) runs across the Independent and Catholic Systems, and the Department of Education. The project has three main areas of professional development — raising awareness of numeracy in teachers and students; providing support for schools in writing numeracy submissions seeking funding to enhance numeracy; and providing support for schools on an individual basis to achieve a culturally sensitive numeracy curriculum. Given the large proportion of teachers who undertake their initial teacher education in other states, the contextual emphasis of numeracy is viewed as an important aspect of their ongoing professional development (Scott, 1998).

Catholic Education Sector initiatives

A Catholic Education Numeracy Project (Parker, 1998) aimed at developing a vision for numeracy education within a Catholic education perspective has been operating in South Australia since 1997. The three year project intends to help teachers increase their understanding of how children construct mathematical knowledge and develop numeracy. Thirty-three 'invited' teachers meet as a group two full days and two after school sessions a term for inservicing, discussions and critiquing of their classroom practices. Project consultants provide additional support to help them plan and implement changes to their classroom practices on an individual basis. While full or partial funding is available from the Catholic Education Office, schools are asked to support their teachers by providing release time for the two full days per term and two more days to assist with the production of written materials. In addition, one hour release time per teacher, three times per term is required for planning with a consultant following 'in classroom' support.

The initial role of the project has involved the key teachers developing a shared understanding of what numeracy is in the context of a Catholic education perspective. It is expected that the key teachers will then assume leadership roles within their schools and the broader Catholic sector as they help develop an awareness of the issues involved in numeracy and support the development of

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numeracy across all curricula. Another expected outcome of the project is for the key teachers to produce written material to support other teachers to develop their understanding of numeracy. Such material 'will describe the mapping of children's thinking and the strategies used to support and challenge their numeracy'. (Parker, 1998, p. 16).

An Asian perspective on professional development of teachers

Strategies to promote the professional development of teachers vary from country to country, reflecting their 'cultural embeddedness and the availability of resources' (Shimahara, 1998 p. 451). While Australian and American approaches rely mostly on individuals taking responsibility for their own upgrading of qualifications, a Japanese approach is typically founded on a peer-based model that views teaching as craft and professional development as reproducing and refining craft knowledge and skills. Such a view of teaching means that initial preparation for teaching at university (or any subsequent upgrading of qualifications) is minimal and that opportunities for inservice are conducted mostly in collaboration with one's peers 'in-house' (Hawley & Hawley, 1997).

A common type of inservice education in Japan involves the use of demonstration classes, where peers collaborate to help each other prepare for their lessons. After a demonstration class, staff meet to review and critique the lesson. The demonstration class is endorsed by Japanese teachers as being the most effective method of enhancing critical reflection on teaching and improving it (Shimahara, 1998).

Another type of inservice that has been in use throughout Japan since 1989, is a one-year government mandated internship program. All beginning public school teachers must enrol in a program consisting of three components: an in-house inservice education component, under the supervision of a mentor, to which approximately ten hours a week are devoted; a program of about twenty lectures and workshops; and ten days of retreats and summer workshops. Each component of the internship is staffed and managed by senior colleagues. Hence, support for teachers relies principally on the reproduction of an existing culture of teaching through the sharing of ideas, beliefs and practical innovations amongst peers (Shimahara, 1998).

Aspects of the Japanese-style inservicing, where the emphasis is on collaboration amongst peers, is a valued component of many professional development initiatives in Australia (for example, the *Catholic Education Numeracy Project* in South Australia). However, to rely almost exclusively on 'in-house' inservicing has some disadvantages: namely, the inability to establish system-wide initiatives, the restricted access to expert knowledge across all curriculum areas, and the

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reproduction of the existing teaching culture with few opportunities for new ideas or knowledge to be introduced from outside the current system.

Aspects of professional development perceived to be effective

The array of professional development initiatives presented thus far was selected merely as a representation of the numerous projects operating nationally and internationally and to convey the extent to which such projects can vary in type and scope. Much of what we know about what makes professional development effective has been compiled in documents such as the *Professional Standards for Teaching Mathematics* (NCTM, 1991), the *Queensland Standards for the Development & Delivery of Professional Development and Training* or made available through providers such as the Centre for Teaching Excellence (Smart, 1998). However, to determine numeracy-related needs we will need to call upon research findings and practical knowledge gained from numeracy-specific projects.

The Australian Association of Mathematics Teachers (AAMT), in collaboration with Monash University, is taking steps to redress this situation with its proposed *Research and Development of National Professional Standards for Excellence in Teaching Mathematics Project*. An aim of the project is to research, develop and document professional standards for teaching mathematics in Australia. It is envisaged that the Standards document, along with an assessment scheme, will be used for the certification of teachers wishing to be recognised in this way. Eventually, initiatives such as AAMT's *Standards Project* will be able to inform developers of professional development about desirable attributes specifically related to the effective teaching of numeracy, but at the moment, we need to draw upon a limited research base and the wisdom gained from exemplary professional development projects operating, to ascertain what can be considered as 'best practice' in teachers' professional development. Before summarising aspects of professional development projects deemed to be exemplifying best practice from a numeracy-specific perspective, I would like to return to a question posed earlier regarding the relationship between effective teachers of numeracy and the type of professional development undertaken by them.

It will be remembered that Askew et al. (1997) found that highly effective teachers of numeracy were distinguished by a commonly held set of beliefs that underpinned a particular series of classroom practices. It is important to ascertain what aspects of professional development could be attributed to the formation of these beliefs and practices which accompany effective teaching of numeracy. In summary, aspects of professional development which highly effective teachers perceived to be helpful included:

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1. the work they were required to do with children, particularly one-to-one interviews with students that focussed on their mental strategies;
2. the use of research data and videotaped interviews with children;
3. the extended time over which the professional development occurred;
4. the mathematics-focussed nature of the professional development;
5. the emphasis on the importance of working with pupils' meanings and understandings;
6. time to examine their own mathematical understandings and strategies;
7. working closely with other teachers, both through planning teaching approaches and in working together in the classroom;
8. a range of outside-school activities and ongoing discussions with other educators.

While there is no 'recipe' for ensuring that professional development will always be effective, comparing the elements of successful professional development programs presented in this paper with the eight aspects emerging from the Askew et al. study, a number of commonalities are evident. Namely, extended time frames, discussion, contextualised professional development, clinical interviewing of children, a research-based approach, and a focus on children's learning strategies.

'Time' emerges as an important element in a number of ways. Professional development that occurs over an extended period of time allows for periods of reflection, the trialling of new approaches, and the provision of feedback. Discussion among colleagues, teachers from other schools and with 'expert' people outside the school environment have been reported as highlights of professional development programs by teachers (e.g. ELRP, *Mathematics Recovery* and CMIT).

Research findings consistently emphasise the importance of mathematics-specific professional development and work-based models in helping teachers put their new knowledge into the specific context of mathematics teaching (Askew, et al., 1997). While work-based learning has its limitations (for example, see Billet, 1998; Retallick, et al., 1994), combined with access to expert others, it provides a valuable vehicle for contextualised learning on an ongoing everyday basis.

Integrating educational research into the professional development program is a key feature of *CMIT* (Wright, 1998), *Cognitively Guided Instruction* (Fennema, et al., 1996), *Mathematics Intervention* (Pearn, 1998a), *First Steps in Numeracy* (Willis, 1997) and many other projects. What, then is the value of educational research for professional development? It is believed that research-based knowledge of students' thinking can help teachers recognise patterns in students' development of understanding. While the *Cognitive Guided Instruction* project showed that a model of primary students'

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thinking can be a tremendous resource for teachers, investigations of projects aimed at secondary students, indicate that similar concise models may be difficult to achieve, as content in higher grades becomes more complex (Gearhart, Saxe & Stipek, 1995). Rhine (1998) contends that it is 'not the acquiring of research-based knowledge of students' understanding, but the process of teachers engaging with that knowledge and considering implications for their instruction' (p. 27) that is the value of adopting a research-based model of professional development. He draws on House's (1996) notion of 'bounded rationality' or the inability of teachers (or any human being) to know everything about every topic they teach, to explain why the transmission of knowledge alone, whether it be based on mathematical content or research-based knowledge of how children learn, does not ensure that professional development will be effective. Rhine (1998, p. 28) suggests that:

> Perhaps the major impact of these projects is due to teachers' paradigm shift away from a focus on teaching and toward a focus on students' learning. Instead of teachers reflecting on what students are doing, they appear to begin to consider what students are thinking and understanding and how that influences what they do in the classroom.

A possible explanation then of why the research-based professional development model is considered to be so effective, is the fact that they all usually include the examination of videotaped clinical interviews with students. A major outcome of this practice is a shift in teachers' focus toward students' learning and thinking. Hence, while research-based knowledge of students' thinking strategies can help teachers map the development of children's mathematical understanding, it is unrealistic to expect teachers to develop expertise in all content areas (or even *all* aspects within one content area). More important is the development of skills designed to monitor and analyse students' thinking strategies and the skills needed to access 'good' research-based resources from which instruction can be planned (for example, see Melbourne University's internet site on decimals at http://online.edfac.unimelb.edu.au/485129/DecProj/index.htm, Mousley and Sullivan's (1996) CD-ROM *Learning about Teaching* and the video included in the CMIT professional development package produced by DET, 1998). This means that professional development should include training for teachers so they can employ research-based resources.

Summary of professional development for practicing teachers

In summarising the professional development initiatives across Australia, it is evident that:

1. The majority of numeracy related projects are focussed on the early years of schooling. However, initiatives of note, which take a broader focus, include the

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Catholic Education Numeracy Project operating in South Australia, and the *Numeracy Across the Curriculum Project* in Western Australia.

2. There are professional development initiatives specifically related to numeracy, operating in all states and territories, but they do not always include all educational sectors. For example, the Catholic and Independent education sectors in NSW are not implementing CMIT. Other projects, such as *Flying Start Numeracy* in Tasmania and *First Steps Numeracy* in Western Australia, are yet to be implemented fully.
3. While the effectiveness of projects, such as the *Mathematics Intervention Study* in Victoria and CMIT are well documented, there is a need for similar monitoring, reporting of outcomes and dissemination of information concerning other projects.
4. Projects considered to be 'proactive' mechanisms of professional development usually involved some form of mentoring system — not unlike the system of professional development operating in Japan. While most do not specifically address numeracy, the positive evaluations indicate the potential they might have, particularly for new and beginning teachers, when operating in conjunction with other projects such as CMIT.
5. Research findings and evaluations of professional development projects considered to be effective, reveal several commonalities. These include extended time frames, discussion, contextualised professional development, clinical interviewing of children, a research-based approach, and a focus on children's learning strategies.

Preservice teacher education

Recruiting good teachers must be a priority of all schools and systems, both government and non-government, if we are to achieve quality educational outcomes (Kemp, 1997, p. 8).

The necessity to recruit 'good' teachers has focussed attention on the quality of students entering and exiting preservice teacher education programs for some time and has prompted initiatives such as the Ministerial Council on Education, Employment, Training and Youth Affairs (MCEETYA) Teacher Recruitment Taskforce. The main purpose of the taskforce was to develop a national recruitment strategy that could be implemented by states and territories to meet local needs. Work has continued on the examination of the cost benefits of collaboration between states and territories to produce national campaign materials. A further initiative by MCEETYA is the establishment of a taskforce to inquire into the skills base and

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qualifications of teacher education graduates, to establish whether the needs of employers are being met now and for the future.

Attempts to codify and prescribe the elements that should characterise preservice teacher education programs are also a result of long-term concerns about the quality of our teaching workforce. For example, the report of the national standards and guidelines for the initial teacher education project, *Preparing a Profession* (Australian Council of Deans of Education, 1998, p. 14), states that graduates should be 'adequately and confidently numerate, and possess knowledge and understanding of numeracy as a fundamental component of learning, performance, discourse and critique across all areas of the curriculum, in particular within their own curriculum levels and areas'. While the document provides an indication of desirable attributes graduates should possess regarding numeracy, it does not articulate a mechanism to ensure the development or assessment of such characteristics. Before discussing some of the ways in which educational systems and preservice teacher education programs have sought to address these concerns, it is important to set the context in which such initiatives are being made.

Enrolments in initial teacher education programs grew from 37 521 in 1995 to 39 128 in 1996, or 4.2 per cent across Australia (MCEETYA, 1998). Of these, 13 364 were enrolled in initial primary teacher education programs and 13 256 were enrolled in initial secondary teacher education programs. In 1997 enrolments grew to 14 549 for initial primary teacher education with a new intake of 5912 students and to 14 679 for initial secondary teacher education with a new intake of 6896 students (DEETYA, 1998b). While primary and secondary preservice teacher data indicate an increase in numbers commencing initial teacher education, the number of students graduating from preservice education programs actually fell in 1996 relative to the previous year's totals. 3710 students graduated from initial primary teacher education programs and 4427 from initial secondary teacher education programs in 1995 whereas in 1996 there were 3130 primary teacher graduates and 4060 secondary teacher graduates. While no breakdown of figures for secondary teachers into specific subject areas are available, it has been noted that enrolments in secondary mathematics teacher education programs across Australia have continued to decrease since the early 1990s (DEETYA, 1998c; DEETYA, 1998d). The Graduate Careers Council of Australia (1997) reports that of the 73.4 per cent of initial education graduates available for full-time employment in 1996, 78.7 per cent were in full-time employment. Of those working full-time, 32.7 per cent were employed as primary school teachers, 25.6 per cent were employed as secondary school teachers and 9.7 per cent were employed as pre-primary teachers. The remainder were full-time employed in other occupations such as management, clerical or sales and services.

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In short, there is currently an oversupply of primary and secondary school teachers with only a small percentage of new graduates gaining full-time teaching positions each year. However, the demand for secondary mathematics teachers is expected to rise in the medium to long term given the continuing low enrolments in secondary mathematics education programs and the anticipated increase in age-related attrition of teachers (DEETYA, 1998d).

Concern over the general quality of our teacher supply has been an issue throughout Australia for some time now. Investigations initiated by these concerns have emphasised the shortcomings of our present teacher education programs. Namely, that the 'end-on' Graduate Diploma of Education is inadequate preparation for teachers and that 'the approach to teacher education to date has been too narrow and restrictive, and in a number of cases, not closely enough related to reflective thinking about the practice of teaching' (Schools Council, 1990, p. 88). A study by Ballantyne, Hansford & Packer (1995) showed that beginning teachers shift rapidly from progressive, student-centred teaching approaches toward more traditional, teacher-centred approaches in the face of everyday school life. However, they also found that graduates of 'critically reflective' teacher education programs retain their progressive, student-centred attitudes and ideals in spite of the pressures and constraints encountered in the classroom. Unfortunately, research by Frid, Redden and Reading (1998) indicates that even after experiencing course work that explicitly addressed reflection, 'students' attempts at reflection were more superficial' than had been expected. They concluded that the 'development of reflective capacities is "hard work"' and much practice is required for it to be developed (p. 208).

Results of investigations in Australia (e.g. DEET, 1991) and overseas (e.g. Askew et al., 1997) reveal that many teachers consider their preservice preparation to be inadequate, describing it as 'neutral' at best and 'useless' at worst (DEET, 1991). In their study of teacher effectiveness, Askew et al. (1997) found little association between initial teacher education and a teacher's ability to teach numeracy effectively. More to the point, teachers did not *perceive* their initial training as an important feature in their development as a teacher of numeracy. While there are few studies dealing specifically with the link between initial teacher education and the effective teaching of numeracy to collaborate this finding, Askew and his colleagues suggest that many of the teachers sampled had considerable teaching experience and therefore 'that sort of thing was in the dim and distant past' (p. 79). In addition, many were only one year educated and indicated that their programs were so rushed that there was insufficient time available to properly prepare them for teaching mathematics.

In another, related body of literature, it has been confirmed that a large proportion of preservice primary teachers not only hold negative attitudes toward mathematics and possess poor attitudes toward the teaching of it, but lack the knowledge and

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confidence to teach mathematics effectively (Bobis & Cusworth, 1994; Speedy, 1989). These findings have important implications for the successful teaching of numeracy at the primary school level with research evidence suggesting that teachers with low mathematics self-concepts may undermine the potential of students to learn, appreciate and react positively to mathematics concepts (Relich, 1992). In addition, despite a decade of Girls' Education Strategies, it seems that girls' confidence in mathematics remains lower than that of their male counterparts. This is of particular concern for investigations into mathematics attitude, since primary teaching is traditionally dominated by females.

In response to these perceived shortcomings of our initial teacher education students and programs, recommendations for significant change in the way our initial teacher education programs are structured and reconceptualised have been and continue to be made. In regard to mathematics, *The Discipline Review of Teacher Education in Mathematics and Science* (Speedy, 1989, p. v) made 63 recommendations to school systems, government agencies and higher education institutions aimed at enhancing 'the general proficiency of the teaching workforce' in mathematics and science. A report on the implementation of recommendations in the review concluded that while the Speedy Report had a 'discernible impact' upon teacher education in mathematics and science, the extent to which the recommendations were implemented had been disappointing (Whitehead, Symington, Mackay & Vincent, 1993, p. xiii). The study suggested that 'releasing a Report is in itself inadequate, irrespective of the quality... A Review is likely to have greater impact if the Report is supported by an implementation plan' (p. xii). For instance, it was found that only a few institutions provided formal pre-testing and remediation programs in mathematics for their preservice teachers as recommended in the Speedy Report. Further, while most institutions had increased time devoted to studies in mathematics as recommended, changes to priorities within institutions brought about by subsequent educational reports, amalgamations, the change in the balance between supply of teacher education graduates and demand, and the need for educational institutions to reduce expenditure, have hindered the implementation of the recommendations.

Subsequent to the Speedy Report, the continuing concern for the level of entry and exit standards for preservice teachers has resulted in universities and educational systems adopting various approaches to deal with students' poor attitudes toward mathematics and lack of skills and understanding in regard to numeracy (Clarke & Clarke, 1996). For example, to gain entry into primary teacher education programs in Tasmania, students must have Year 12 mathematics and in NSW all primary teachers intending to teach in government schools need to have studied 2 units of mathematics (and English) at the HSC level or its equivalent. Many institutions have implemented mathematics subjects, intent on developing preservice teachers' own

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mathematical knowledge and appreciation of the subject. Flinders University, South Australia, for instance, requires its primary and middle school students in the first year of their Bachelor of Education to undertake a subject 'Maths for Primary Teachers', in which aspects of numeracy are addressed. Similarly, primary preservice teachers in the first year of their Bachelor of Teaching programs at the University of Western Sydney, Macarthur and University of Technology, Sydney, are required to take a mathematics subject designed to develop more positive attitudes toward mathematics and to enhance their own knowledge of the subject. At the Royal Melbourne Institute of Technology (RMIT) all primary, early childhood and secondary preservice teachers are required to undertake a two semester length subject — 'Introduction to mathematics and numeracy' — as part of an initiative to enhance the personal numeracy skills of the students and to provide a generic introduction to teaching mathematics at all levels and across the curriculum. Preservice teachers can also get assistance from the study skills centres and learning centres operating within most universities to enhance their own numeracy levels.

As mentioned earlier, the notion of increasing the mathematics content knowledge of our teachers may not be sufficient to improve the ability of our teachers to teach numeracy more effectively, particularly at the primary school level. For example, Clarkson (1998) reports the results of primary preservice teachers on a mathematics test at the conclusion of a mathematics component at the end of their first year of university. Findings indicate little difference between the mathematical ability of students who had completed Year 11 and 12 mathematics and those who had not. This indicates that manipulation of entry criteria to teacher education programs has had 'little direct benefit as had been hoped' (p. 175). An implication of the Speedy Report recommendations and the directive of the NSW Department of Education and Training is that extra units of mathematics would bring all students up to an acceptable standard in mathematics. However, findings by Clarkson suggest that such measures are inadequate. Simply undertaking more mathematics courses is not going to be sufficient for preservice teachers if long-term problems in numeracy exist. It must be remembered that 'mathematics' does not equate to 'numeracy' and that while numeracy involves aspects of mathematics, mandates that require preservice teachers to undertake more mathematics content-based subjects, will not necessarily address the wider dimension inherent in our understanding of what it means to be numerate.

The trend towards increasing years of initial study from 3 years to 4 years and the gradual demise of the 1 year Diploma of Education program from many institutions is also in response to the call for better quality graduates and programs. For example, the University of Sydney, University of Western Sydney, Nepean, Queensland University of Technology and Newcastle University have replaced their graduate diploma programs with 2 year, full-time Master of Teaching programs for initial

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teacher education. While teacher education institutions in some states, such as NSW, are still moving towards 4 year tertiary preservice programs, other state educational systems, such as Queensland, only offer approved 4 year teacher education programs.

Information technology and preservice teacher education

The use of information technology (IT) is becoming pervasive in many teacher education programs and preservice teachers are now required to be IT literate. While the number of university courses being offered where all contact with lecturers is via on-line conferencing or email is still very small to date, most teacher education institutions now integrate aspects of computer technology into their programs. For example, the Master of Teaching program at the University of Sydney has its own web page where all course information is posted. Students are offered the opportunity to communicate with lecturers via email in addition to the more conventional means and to work on assignments cooperatively with students — building upon the responses of other students through a web-based system of information sharing. Schuck and Foley (1998) at the University of Technology, Sydney, have explored the potential of web-mediated conferencing so as to include elements of flexible learning into their mathematics education courses. They consider it to be a promising avenue for teacher education for the next millennium because it 'offers immediacy of access to information that is up to date and world-wide in scope' (p. 2), but caution that difficulties encountered with the technology can actually cause students to develop negative attitudes towards the use of computer conferencing. They suggest that ongoing technical support and information about the limitations of the tool are essential to minimise frustration and resentment of the technology.

The ability to access the electronic media provides preservice teachers with a lifelong skill for enhancing their own professional development. Through it they can access not only research-based information, but practical ideas for the classroom. For example, Melbourne University's decimal internet site combines the latest research findings with information about using concrete materials in interesting ways. Other sites, such as the *NRICH Online Maths Project* (http://www.nrich.maths.org.uk) and National Council of Teachers of Mathematics' web site (www.nctm.org) have been recognised internationally for the assistance they can provide to preservice and inservice teachers. CD-ROMs, such as those produced by Mousley & Sullivan (1996) and Herrington, Sparrow, Herrington & Oliver (1997) provide flexible teaching resources for teachers at all stages of their professional development. Hence, instruction in the use of technology-based resources is fast becoming a critical skill

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for our teachers of the future. Such skills provide avenues for continuous and autonomous professional development opportunities.

Summary of preservice teacher education issues and concerns

In response to continuing concerns about the quality of our teacher education graduates, institutions have sought to restructure and reconceptualise their preservice programs in various ways. The conference 'Showcasing Excellence in Initial Teacher Education' hosted by the Royal Melbourne Institute of Technology in February 1999, is an example of how the successful initiatives can be shared amongst those in pursuit of the same goal.

In short, some of the issues regarding initial teacher education, particularly in regard to numeracy but not exclusively, include:

1. The concern over poor attitudes and low levels of confidence towards mathematics of primary preservice teachers
2. The continuing low enrolment rate into secondary mathematics teacher education programs
3. The lack of mathematical skills and understandings of preservice primary and non-mathematics secondary teachers
4. The perception of many teachers that their initial teacher education was inadequate
5. The concern that many graduates revert to more teacher-centred approaches once they are faced with the realities of the classroom; and
6. The concern that many teacher education programs are not based enough on critically reflective practice.

Each of these concerns has been the impetus for changes within faculties of education. In some instances it has resulted in a total restructuring and reconceptualisation of the way initial teacher education programs are conducted, such as the utilisation of a case-based approach in the Master of Teaching program at the University of Sydney. In other instances it has been the addition of more subjects with a focus on numeracy. Some initiatives have been shown to be insufficient to ensure that graduates will be able to teach numeracy effectively, such as the instigation of 2 units of mathematics to HSC level as a criterion for entry to teacher education. Other initiatives that have shown some benefits include an emphasis on:

- critically reflective practice;
- encouraging preservice teachers to scrutinise their own beliefs and attitudes regarding mathematics;

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- research-based knowledge and the skills to access such information.

As with the professional development of practising teachers, there can be no one approach that will ensure all preservice teachers will graduate as effective numeracy teachers. While it may be naive to expect that change in the structure of the initial education of teachers alone will ameliorate all concerns relating to the quality of the teacher workforce, it is a view expressed by government bodies that to 'get it right' at the start of a teacher's education may help alleviate many other sources of difficulty (NBEET, 1990).

Professional development of teacher educators

Calls to improve the quality of our teachers have also had an impact on the status of teacher educators. A recent survey of tertiary mathematics departments revealed a 20 per cent decrease in mathematics staff over the period 1995–1998 (MERGA Newsletter, 1998). A survey of teacher education institutions is about to investigate similar reports concerning the declining numbers of tertiary mathematics educators across Australian universities.

While it is essential to attract highly qualified, younger staff to tertiary mathematics education, it is also important that existing educators develop professionally. There is little doubt that mathematics educators serious about developing professionally, would involve themselves in the many conferences organised and read and write for the journals published by professional organisations, such as the Australian Association of Mathematics Teachers, the National Council of Mathematics Teachers, the Mathematics Education Research Group of Australasia and the large number of regional organisations (e.g. Mathematics Association of Victoria) and the like. However, such activities have not helped raise the general credibility of university educators. For example, the old chant — 'Those who can't teach, teach teachers and those who can't teach teachers, do research' — does little to enhance their profile in the eyes of the general community (Sydney Morning Herald, Monday 16th November, 1998).

The opportunity to conduct professional reading, discuss and listen to the current theories of education, to attend conferences and interact with other educators from around the world via the information technology readily available at universities, would certainly impact upon the personally held theories and beliefs of tertiary educators over time. However, difficulties often arise when such changes call for different classroom practices to be expounded to prospective teachers, without the tertiary educator having had the opportunity to reflect upon these practices. For example, recent changes to the mathematics curriculum documents across Australia, such as the inclusion of working mathematically and chance and data into many

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state primary syllabus documents, and the focus on open-ended problem solving at both the primary and secondary levels, means that while tertiary educators may be familiar with the underlying philosophies of new approaches, or be aware of the content of new strands, they will not have had the benefits of implementing these changes. 'Reflection on such changes will yield modifications to personal beliefs, theories and course outlines at the tertiary level, but reflection on practice at the school-level is often lacking' (Bobis, 1998, p. 34). Such concerns over the perceived gap between many teacher educators and the realities of school experience have been a criticism aimed at teacher educators around the world and have implications for their professional development (Eltis, 1994; Schools Council, 1990). In some states of the USA, legislation has been in place since 1980 to address the need for teacher educators to regularly return to the classroom (Hopkins, 1984). British educators have been required to teach successfully in schools for one term every five years (or equivalent) since 1989 (Beattie, 1991). In 1991, the then Minister for School Education in NSW suggested that all tertiary educators return to the classroom for three months every five years so that they might be 'in touch' with the realities of actual classroom teaching (Chadwick, 1991).

While the notion of teacher educators remaining in touch with school and classroom realities is considered crucial if they are to maintain their credibility in the eyes of their preservice teachers and the general community, the practicalities of returning to the classroom every few years makes it unworkable for many academics. For this reason, the minister's suggestion has largely been rejected by faculties of education. However, educational institutions acknowledged the legitimacy of the proposal and have adopted various alternatives to address the concern. For example, the Faculty of Education at the University of Western Sydney, Macarthur, initiated a visiting teaching lecturer program in 1992 (Perry, Walton & Conroy, 1998). Applications from teachers with a minimum of four years' teaching experience; appropriate tertiary qualifications; demonstrated excellence in teaching; an ability to assist with the supervision of practicum; and expertise in one or more areas of the teacher education curriculum are considered for a visiting teacher's position in either the Secondary, Primary or Early Childhood teacher education courses each year for a duration of six to 12 months. An evaluation of the program revealed that it had positive professional development implications, albeit on an ad hoc basis, for a number of individuals — for the visiting teachers themselves, and for the university lecturers with whom they came into contact.

Another alternative that is gradually growing in popularity is the existence of professional partnerships between teacher education institutions and schools. For instance, a recent advertisement for a lecturer in primary mathematics education at the University of Sydney stipulated that 'the applicant must be willing to engage in professional partnerships with schools and other organisations, for the improvement

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of professional practice and pedagogy...' (Sydney Morning Herald, Saturday, 30th October, 1998, p. 9).

For more than a decade, the rhetoric has called for teacher educators to establish collaborative relationships between the major stakeholders in education in the attempt to enhance teacher education at all levels (Speedy, 1989). Until recently, there was little recognition at the university level for academics who become involved in schools, but recent emphasis on university involvement in school renewal processes (Eltis, 1994; Sachs, 1997) recognises that such partnerships can improve the professional practice and pedagogy of teachers *and* academics. Departmental calls for teacher educators to have recent and relevant classroom experience (Chadwick, 1991) and government reports emphasising repeatedly the necessity for partnerships to be forged between teacher education institutions and schools (Retallick et al., 1994; Speedy, 1989), combined with the growing acceptance of collaborative action research projects in academic sectors as scholarly research (Mousley, 1992), is making the notion of partnerships with schools and other professional organisations a necessity, if faculties of education wish to maintain their credibility not only with schools, but with the general community.

In reports on the impact of a school-university partnership in the area of mathematics, it was noted that such relationships had the potential to enhance the quality of mathematics at all levels of education (Bobis, 1998; Bobis & Aldridge, 1995). Not only did it allow the mathematics educators to gain recent and relevant school experience, but it had implications for the professional development of the teachers involved, benefits for the children involved and benefits for the preservice teachers who attended practicum at the school and who were taught by the mathematics educators at university. Such reports support recommendations that if faculties of education wish to enhance teacher education and be 'agents of change', the best place to start is by forging 'partnerships between faculties and broad school systems' (Hargreaves, 1997). Hence, improving the quality of teaching and learning among teachers at all stages of their careers, should be a concern of those responsible for initial teacher education. However, it has been argued that 'in these days of downsizing in universities...we (mathematics educators) are no longer in a position to help with long term solutions' for those experiencing difficulty teaching mathematics (Clarkson, 1998, p. 175). Perhaps this problem could also be 'down-sized', if more mathematics educators adopted the view that initial teacher education and the ongoing professional development of practising teachers and teacher educators are integral parts of the same desire to enhance numeracy and that school-university partnerships provide a good place to start.

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Conclusion

The National Plan for Literacy and Numeracy calls for 'comprehensive assessment of all students... in the first years of schooling with the purpose of adequately addressing their literacy and numeracy needs and identifying... students at risk'. Such a plan has been congratulated by organisations concerned with numeracy education around Australia. However, it also poses an important challenge for our teachers — that is, to implement the National Plan. How well placed are our teachers to implement the Plan? Are they aware of it? Do they have the necessary identification and intervention skills necessary or is further education required? What outcomes do we need from initial teacher education and from professional development in terms of the National Plan?

The growing popularity of professional development programs such as *Count Me In Too*, *Mathematics Recovery* and the *Early Numeracy Research Project* seem to confirm, that despite the experienced nature of our teaching workforce, there is still a need to provide additional support to teachers. While a more informed personal knowledge base is desirable, it is not sufficient to ensure that the National Goal can be reached. First and foremost, all who have a stake in education need to be aware of the National Plan and their responsibilities towards achieving it.

In regard to implementing the Plan, professional development will need to address a range of areas. For non-mathematics teachers at the secondary level, this might not mean an emphasis on the 'mathematical' aspects of numeracy, but on numeracy in context across the curriculum. For primary and secondary mathematics teachers, it is more likely that they will need to focus on both the 'mathematical' and 'non-mathematical' aspects of numeracy. Additional priorities for professional development programs are summarised in The Report of the Numeracy Education Strategy Development Conference, *Numeracy = everyone's business* (AAMT, 1997, p. 32–33), and include:

1. The cross-curricula nature of numeracy;
2. Understanding of, and effective responses to, the cultural context of numeracy and developing cross cultural perspectives;
3. How children learn mathematics and how they learn to be numerate;
4. Teachers' knowledge of mathematics and how it is integrally part of learning across the curriculum and, particularly in the case of specialist teachers outside of mathematics, in their area of expertise;
5. The importance of disposition and positive attitude in the development of numeracy, and how these orientations can be fostered; and
6. Appropriate and constructive procedures for assessing numeracy.

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Current trends in professional development seem to emphasise early numeracy. As indicated by Pearn (1998b), there is a need for this emphasis to be extended to teachers beyond the first few years of schooling. It also needs to infiltrate more educational systems.

Preservice teachers are in the optimum position to be made aware of the National Plan and their responsibilities towards achieving it. However, as discussed previously, the skills and strategies that they might possess on graduation may never be utilised if they are not also being used by 'real world' schools. It has been suggested in this paper, that initial teacher education and the ongoing professional development of teachers should not occur in isolation, but be viewed as integral components. A suggested strategy to achieve this, is to encourage more collaboration between educational systems and faculties of education, such as school-university partnerships. Such relationships have the potential of enhancing numeracy at all levels of education.

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